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DOI:

[10.1093/aje/kwx092](https://doi.org/10.1093/aje/kwx092)

*Document Version*

Peer reviewed version

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*Citation for published version (APA):*

Chang, V., Alley, D., & Dowd, J. B. (2017). Trends in the Relationship of Obesity and Disability, 1988-2012. *American Journal of Epidemiology*. <https://doi.org/10.1093/aje/kwx092>

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**Trends in the Relationship of Obesity and Disability, 1988-2012**

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Running Head: "Obesity and Disability"

Abstract word count: 200  
Text word count: 3545  
Tables: 3  
Figures: 1  
Web table: 1

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Abbreviations:

ADL = activities of daily living

BMI = body mass index

CI = confidence interval

NHANES = National Health and Nutrition Examination Surveys

OR = odds ratio

PAF = population attributable fraction

## ABSTRACT

Rising obesity rates coupled with population aging have elicited serious concern over the impact of obesity on disability in later life. Prior work showed a significant increase in the association between obesity and disability from 1988-2004, calling attention to disability as the cost of longer lifetime exposures to obesity. It is not known whether this trend has continued. We examined functional impairment and activities of daily living (ADL) impairment (defined as severe and moderate to severe) for adults aged 60 and older (N=16,770) over 3 periods in the National Health and Nutrition Examination Surveys. The relative odds of impairment for obese vs. normal weight individuals significantly increased from period 1 (1988-1994) to period 2 (1999-2004) for all outcomes. In period 3 (2005-2012), this association remained stable for functional and severe ADL impairment, and *decreased* for moderate to severe ADL impairment. The fraction of population disability attributable to obesity followed a similar trend. The trend of an increasing association between obesity and disability has leveled off in more recent years, and is even improving for some measures. These findings suggest that public health and policy concerns that obesity would continue to get more disabling over time have not been borne out.

## KEYWORDS – MeSH Terms

Activities of daily living

Body mass index

Disability Evaluation

Obesity

The decline in late-life disability at the close of the 20<sup>th</sup> century in the United States has countered fears over the potential impact of population aging on the nation's health care needs (1-3). However, increases in the prevalence of obesity could reverse these trends, potentially wiping out improvements in disability (3, 4). Obesity is associated with a range of limitations in mobility as well as self-care needs (5, 6).

The changing relationship of obesity to health outcomes is currently the subject of spirited debate (7). While obesity is clearly associated with increased risk for various adverse outcomes, there are signs that the obese population may be growing healthier over time. For example, the obese population has experienced major declines in cardiovascular risk since the 1960s, including a decline in the excess risk of high cholesterol relative to normal weight persons (8). Additionally, evidence is accumulating that the risk of mortality associated with obesity has declined, especially for cardiovascular mortality (9-11). However, obese individuals in more recent cohorts are experiencing a greater lifetime exposure to excess weight due to a combination of earlier onset of obesity and increased longevity (12), with important implications for conditions such as arthritis (13). These competing trends raise the question of whether persons who are obese are living longer with better-controlled risk factors but, paradoxically, experiencing more disability.

In a previous study (14), we found significant changes to the association between obesity and disability from 1988 to 2004 for adults aged 60 years and older using data from National Health and Nutrition Examination Survey. Obesity at a given age was associated with a much higher risk of disability than it was in the past, calling attention to disability as the price of a longer life with obesity (15). In this study, we update our analyses to 2012 and examine how

the overall association between obesity and disability has changed over a quarter century. A continued increase in the strength of this association would lend support to the concern that obesity will ultimately reverse declines in disability. We also extend our prior analysis by examining change in the fraction of population-level disability that is attributable to its association with obesity. These estimates combine *prevalence* data on obesity with measures of association at the individual level, allowing a broader characterization of obesity in population-level disability. This assessment is particularly critical because the prevalence of obesity in mid- to late-life has been increasing over this period (16-19).

## METHODS

### Data

The National Health and Nutrition Examination Surveys (NHANES) are nationally representative, cross-sectional studies of the non-institutionalized U.S. population conducted by the National Center for Health Statistics with interviews and clinical examinations. Data from NHANES III (1988-1994) and the continuous NHANES from 1999-2012 were used to examine the association between obesity and disability over time. NHANES waves prior to NHANES III do not include our measures of interest on disability. Our sample consists of persons aged 60 years and over who participated in both the interview and examination components. Because screening questions for disability-related outcomes changed over these periods, consistent data are only available for those aged 60 and over.

### Measures

The NHANES collected information on functional limitations, which refer to restrictions in basic movements, and limitations in activities of daily living (ADL), which represent more severe disability and reflect a person's ability to live independently. These domains are conceptually distinct, as functional limitations reflect mobility and are intrinsic to the individual (e.g., the ability to crouch), while ADL limitations reflect an interaction with the environment (e.g., dressing) (20). For each disability-related task, respondents were asked, "By yourself and without using any special equipment, how much difficulty do you have" with the particular task. Respondents could report having "no difficulty, some difficulty, much difficulty, or unable to do". Respondents were coded as having a functional limitation if they reported "much difficulty" or "unable to do" any of the following 6 tasks: walking one-fourth of a mile, walking up 10 steps without resting, stooping/crouching/kneeling, lifting or carrying 10 pounds, walking between rooms on the same floor, and standing from an armless chair. Participants who reported using assistive devices to walk were assumed to have difficulty walking one-fourth mile and walking up 10 steps. Respondents were coded as having an ADL limitation if they reported "much difficulty" or "unable to do" any of the 3 following tasks: getting in and out of bed, eating, and dressing. Because the prevalence of this outcome was low (<5%), we also ran models including "some difficulty" with the ADL tasks, a broader definition that has been used in other studies (21, 22). These two versions of ADL disability are labeled "severe" and "moderate to severe" impairment. Respondents were included if they answered at least 4 of the 6 functioning questions and at least 2 of the 3 ADL questions, resulting in less than 1% who were excluded for missing data on disability.

Measured height and weight were used to calculate body mass index (BMI: weight [kg]/height [m]<sup>2</sup>) and define standard weight categories: underweight (BMI < 18.5), normal weight (BMI 18.5-24.9), overweight (BMI 25.0-29.9) and obese (BMI ≥ 30.0). BMI was missing for 2.9% of respondents. Time was divided into three periods: period 1 (NHANES III, 1988-1994), period 2 (1999-2004), and period 3 (2005-2012). Periods 1 and 2 conform with our prior study (14). Period 3 represents the more recent waves of data. While these time periods represent a logical extension of prior work, we also used alternative specifications to explore within-period trends.

Covariates included age, sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other), education, income, and smoking. Age was top-coded at 90 (i.e., ages >90 coded as 90) in NHANES III, 85 from 1999-2006, and 80 from 2007-2012. We change the top-code in NHANES III to 85. We also conducted sensitivity tests with (a) all respondents top-coded at 80 and (b) multiple imputation for all censored ages. These alternative specifications yielded very similar findings. Education was categorized by years (< 12, 12, 13-15, and ≥16). The poverty income ratio was used to adjust income for household size and inflation. For the 10.2% of respondents missing data on income, poverty income ratio was imputed using random regression imputation. Smoking was coded as current vs. nonsmoker. We also considered the influence of adjusting for several chronic conditions that could be on the pathway between obesity and disability. Here, participants were asked whether a physician had ever told them that they had arthritis, asthma, diabetes, congestive heart failure, a heart attack, cancer, or stroke.

## Statistical Analyses



We used logistic regression to (separately) model the odds of having a functional or ADL limitation as a function of weight status, time period, and obesity interacted with time.

Allowing for additional interactions between overweight and time did not meaningfully change our findings. All primary models adjust for age, sex, race/ethnicity, education, income, and smoking. Secondary models further adjust for chronic conditions to assess their potential role in mediating changes over time. Population attributable fractions estimate the proportion of disability that can be attributed to its association with obesity. They were calculated for each disability outcome and period by comparing the observed prevalence of disability with a counterfactual scenario where persons who are obese experience the same odds of disability as those who are normal weight, adjusting for covariates. All analyses accounted for the complex design of the NHANES using the “svy” commands (23) in STATA 13.1 (StataCorp, College Station, TX).

## RESULTS

Table 1 shows the prevalence of obesity and the unadjusted prevalence of disability within BMI categories. Over the three periods, the prevalence of obesity rose from 23.5% to 36.0%.

Functional impairment declined for the normal and overweight groups but not the obese. ADL impairment declined for severe impairment among the normal ( $P = 0.06$ ) and overweight ( $P = 0.02$ ) groups.

Table 2 provides odds ratios (ORs) for functional and ADL impairment (see Web Table 1 for full regression results). The ORs for the obese-period interactions indicate change in the

association between obesity and disability for period 2 compared to period 1, and for period 3 compared to period 1, respectively.

Model 1 adjusts for demographic characteristics and smoking. For functional impairment, the main effect of obesity shows greater odds of impairment for obese vs. normal weight in period 1 (OR=1.96, 95% confidence interval (CI): 1.62, 2.36). The main effects for time were not significant, suggesting that the odds of impairment did not change for non-obese individuals. The interaction terms for obesity and time were positive and significant for both time periods, indicating that the relative odds of being functionally limited were significantly higher for periods 2 and 3 compared to period 1. The OR for obese increased to 3.10 (1.96 x 1.58 [95% CI: 2.69, 3.57]) for period 2, and it was 2.87 (95% CI: 2.51, 3.27) for period 3. These calculated values are shown in the last two rows of the table. There was no significant difference in the association of obesity with impairment for period 2 vs 3 ( $P = 0.35$ ). While the excess risk of functional limitation associated with obesity is still higher than it was in period 1, it has not gotten worse in recent years.

For severe ADL impairment, Model 1 shows that the odds of impairment for the non-obese had significant declines in both period 2 (OR=0.66, 95% CI: 0.50, 0.88) and period 3 (OR=0.72, 95% CI: 0.56, 0.92) compared to period 1. For respondents who are obese, these declines were not seen: period 2 vs. 1 OR=1.03 (0.66 X 1.55 [95% CI: 0.70, 1.49]), period 3 vs. 1 OR=1.11 (95% CI: 0.76, 1.62). Since the non-obese experienced improvements but the obese did not, the OR for obesity went from 1.31 (95% CI: 0.93, 1.84) in period 1, to 2.02 (95% CI: 1.44, 2.83) in period 2, and 2.02 (95% CI: 1.44, 2.83) in period 3. Again, the difference in the

obesity-impairment association for period 2 vs. 3 was not significant ( $P > 0.99$ ), suggesting that the increased risk is associated with obesity has not worsened over time.

For the final outcome of moderate to severe ADLs, the main effects for time were not significant in Model 1, suggesting that the odds of impairment did not change for non-obese individuals. The obesity-time interaction was positive and significant for period 2 (OR=1.61, 95% CI: 1.22, 2.12), but not significant for period 3 (OR=1.09, 95% CI: 0.84, 1.40). As such, the OR for obese increased from 1.51 (95% CI: 1.23, 1.85) in period 1 to 2.43 (95% CI: 1.96, 3.01) in period 2, and then *decreased* to 1.64 (95% CI: 1.36, 1.97) in period 3. These differences were significant for period 1 vs 2 ( $P < 0.01$ ) and period 2 vs 3 ( $P < 0.01$ ), but not for period 1 vs 3 ( $P = 0.53$ ). Hence, while the association of obesity with impairment significantly increased from period 1 to 2, this increase was attenuated by period 3 due to declining impairment among persons who are obese from period 2 to 3.

Figure 1 shows these trends computed as predicted probabilities for each of our outcomes based on Model 1. As odds ratios can exceed relative probabilities with common outcomes, we also compute prevalence ratios using adjusted probabilities. For functional limitations, the adjusted prevalence ratios for obese vs. normal weight across the three periods were 1.63, 2.19, and 2.10. For ADLs, these estimates were 1.29, 1.97, and 1.97 for severe impairment, and 1.40, 2.02, and 1.50 for moderate-severe impairment. Some prevalence ratios are weaker, but all exhibit the same time trend as the odds ratios for each outcome.

Model 2 in Table 2 adjusts for chronic conditions that could be on the *pathway* between obesity and disability to assess their potential role in mediating the time-related changes observed in Model 1. Although there was some variation in statistical significance, the

conditions generally exhibited a positive association with disability. The main effect of obesity for each outcome was attenuated when adjusting for the conditions, supporting the expectation that chronic conditions play a role in the disabling effects of obesity. The main effects for period were slightly lower (i.e., stronger), suggesting that changes in the prevalence of conditions may have attenuated underlying declines in disability. Some of the interaction terms between obesity and period were slightly attenuated, and they were no longer statistically significant in severe ADL, suggesting that changes in the prevalence of conditions may have played some role in changes to the association between obesity and disability. A supplemental table shows the estimates for all the covariates in the models.

We examined the potential influence of shifts toward heavier BMIs by subdividing the obese category into classes (class I, BMI 30.0-34.9; class II, BMI 35.0-39.9; and class III, BMI  $\geq$  40) and allowing each class to interact with the indicators for time period (results not shown). Despite some attenuation, we found the same basic trend in class I obesity, suggesting that the changes observed for obesity as a whole were not simply driven by shifts toward more extreme obesity. While class II obesity also showed increases in its association with disability relative to the first period, class III did not, perhaps because its risk in the first period was already very high. We also explored the use of indicator variables for each 2-year sampling period within the continuous NHANES as a more flexible time specification. While there was some wave-to-wave variability and less precision with the use of finer time cuts, these models showed the same overall pattern with respect to change over time.

Table 3 shows population attributable fractions (PAFs). For each outcome, we estimate the proportion of disability associated with obesity in each time period. In keeping with the

pattern of increasing obesity prevalence illustrated in Table 1 and the estimates of differential odds from Table 2, the PAF for all outcomes showed large increases from period 1 to period 3, changing from 9.8% to 23.2% ( $P < 0.001$ ) for functional limitations, from 6.1% to 24.6% ( $P = 0.01$ ) for severe ADL, and from 7.9% to 14.2% for moderate-severe ADL ( $P = 0.06$ ). The point estimates were also higher for period 3 vs 2 for functional limitations and severe ADL, but these differences were not statistically significant. The PAF for moderate-severe ADL, however, was *lower* in period 3 relative to period 2 ( $P = 0.04$ ). This is driven by the fact that the association of obesity with moderate-severe ADL decreased over this time interval. In sum, the PAF for obesity has increased for all three measures of disability from period 1 to 3, but this gain was predominately due to increases that occurred from period 1 to 2.

## DISCUSSION

Rising obesity rates coupled with population aging have elicited major concern over the consequences of obesity for disability in later life. Recent increases in longevity may not be accompanied by a compression of morbidity, resulting in more years spent in an unhealthy state (24, 25). Our prior work showed a major increase in the association between obesity and disability from 1988 to 2004 for persons age 60 and older – that is, an increase not only in the prevalence of obesity, but in the *relationship* of obesity and disability (14). The same weight status at the same age was more strongly linked to disability than in the past, raising the serious concern that obesity is becoming less lethal but more disabling over time. In this study, we examine whether this unsettling trend has continued.

We find that the increasing association between obesity and disability observed for 1988-2004 did not continue over the more recent period from 2005-2012. The excess risk associated with obesity appears to have leveled off. While obesity is still associated with higher rates of both functional and ADL impairment relative to normal weight, this gap has not worsened. Indeed, the obese population is now starting to experience a decline in moderate to severe ADL impairment.

It is not clear why the trend has abated. An earlier age of onset and longer duration of obesity for later birth cohorts would be expected to increase obesity-associated disability (14, 26). Cumulative exposure to obesity is especially salient for disability because of obesity's role in osteoarthritis, chronic back pain, loss of muscle strength, and overall wear and tear on the musculoskeletal system (27). We used NHANES data on recalled weight at age 25 (from 1999-2012) to explore trends in our data. Among those who were obese at the time of survey, BMI at age 25, as well as obesity at age 25, were increasing across waves, adjusting for sociodemographics. This suggests that duration of obesity at a given age was likely increasing over the latter two periods in our study population. Longer survival among persons who are obese (9-11) can also lead to an increase in comorbidity and cumulative exposure to excess weight. While these trends would suggest a continued increase in the association of obesity with disability, we find that the association is stable to improving.

Primary prevention of cardiovascular disease or a reduction in its severity and disabling complications may provide a countervailing influence to longer durations of obesity. Prior work suggests that physicians may be more aggressive in managing risk factors and preventive care for obese relative to normal weight patients (28). Moreover, patients who are obese have a

higher clinical visit frequency and may present earlier in the course of disease (29, 30). The obese population has also experienced a greater decline in the proportion of untreated hypertension and dyslipidemia from 1999-2010 (31). On the other hand, musculoskeletal problems are more difficult to prevent and treat given excess weight, and the prevalence of diabetes continues to be high with a disproportionate share of increases attributable to obesity (32, 33). Adjusting for chronic conditions in our models suggests that an increase in disease prevalence for the obese population may have played some role in a stronger disability association relative to the first period. Future studies should work to detail the contribution of these varied dynamics over time.

Population attributable fraction, or the proportion of disability associated with obesity, has increased from period 1 to 3, but most of this change was due to increases that occurred between period 1 and 2. PAFs depend on both the prevalence of obesity in the population and the excess risk of disability associated with obesity. Our finding of a stable to decreasing association between obesity and disability, together with recent estimates that the prevalence of obesity at younger adult ages is leveling off (19, 34), suggests that PAFs could also stabilize going forward.

While obesity can lead to disability, disability can also increase the risk of obesity, which would strengthen their association. For example, the increasing association over the first two periods may have been driven, in part, by increased longevity among disabled persons and greater risk and opportunity for becoming obese (15). Little is known about the magnitude of a potential causal effect of disability on obesity. Our primary goal was to examine how the *overall association* has changed over time, recognizing that these changes result from the

complex interplay of a multitude of inputs, which can also include the effects of disability on obesity.

There are limitations to this study. First, though measures of association from observational data are frequently used to calculate PAFs, they do not typically reflect causal estimates. For example, the potential for reverse causality and unknown heterogeneity limit the causal interpretation of our measures of association. In this sense, PAFs can overestimate the fraction that is truly “attributable” to the exposure, and the magnitude of our estimates should be interpreted with this important qualification. Our aim was integrate prevalence data with measures of association to offer a more comprehensive picture than either provides in isolation. Second, we used self-reported difficulty with activities rather than objective measures of performance. Though the NHANES has some performance measures, they are not comparable across surveys. Third, the NHANES did not ask about bathing or toileting, additional tasks that can be included for ADLs. While this may influence estimates of prevalence, we were primarily interested in time trends, which would only be affected if the additional items changed differently relative to the measured items. Fourth, it is possible that subjective assessments of what constitutes difficulty, or factors associated with survey participation, may have changed over time. Differential participation would need to correlate with disability, obesity, and time to drive our trends in associations. Acknowledging these limitations, there is much precedent in the literature for using the NHANES to study disability, including ADLs, and the use of self-reported measures to study population trends in disability (1, 14, 21, 22, 35).



While there were large and significant increases in the association between obesity and disability from 1988 to 2004, this trend has leveled off in more recent years, and is even improving for some measures of disability. The increased risk of functional and severe ADL limitations for the obese has remained stable. When the study of ADLs is broadened to include moderate difficulty, the obese population is now starting to experience declines in disability. Though obesity continues to be associated with disability, our findings suggest that public health and policy concerns that obesity would continue to get more disabling over time have not been borne out.

## ACKNOWLEDGEMENTS

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This work was supported by a Clinical Translational Research Award from the American Diabetes Association (7-12-CT-12) to V.W.C. Early versions of this article benefited from presentations at the annual meeting of the Population Association of America (Washington, District of Columbia, April 1, 2016) and the Trends Network meeting held at the University of Michigan (Ann Arbor, Michigan, May 23, 2016).

Conflicts of interest: none declared.

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**Table 1.** Sample Characteristics by BMI Group and Period, Ages 60 Years or Older, NHANES, 1988-2012<sup>a</sup>

Variable	Normal Weight %				Overweight %				Obese %			
	P1 (n=1865)	P2 (n=1239)	P3 (n=1739)	P for 1 vs 3 <sup>b</sup>	P1 (n=2151)	P2 (n=1801)	P3 (n=2469)	P for 1 vs 3 <sup>b</sup>	P1 (n=1262)	P2 (n=1408)	P3 (n=2534)	P for 1 vs 3 <sup>b</sup>
BMI <sup>c</sup>	35.4	28.0	26.1	<.001	38.7	39.0	36.5	0.065	23.5	31.7	36.0	<.001
Functional impairment	22.4	22.7	22.6	0.046	27.3	27.4	27.4	0.001	34.0	34.6	35.2	<.001
ADL impairment (severe)	26.7	26.6	22.5	0.033	27.4	25.8	24.1	0.047	36.8	42.2	38.9	0.362
ADL impairment (moderate-severe)	5.0	3.5	3.3	0.055	4.2	3.0	2.8	0.017	6.0	5.5	5.6	0.682
Mean age (years)	17.7	14.9	15.2	0.147	15.3	17.2	15.0	0.793	22.2	28.7	21.0	0.558
Female	71.4	72.2	71.2	0.630	70.4	71.0	70.3	0.835	69.1	69.0	68.8	0.304
Race/ethnicity	60.2	59.6	61.0	0.662	50.3	51.1	49.0	0.420	61.0	58.8	57.7	0.153
Non-Hispanic white	86.2	82.9	78.8	<.001	85.6	82.0	82.3	0.097	82.4	80.7	78.2	0.078
Non-Hispanic black	6.5	5.8	7.0	0.619	7.5	7.5	6.9	0.556	11.2	11.1	11.6	0.805
Hispanic	3.5	5.4	5.5	0.019	6.1	7.8	7.1	0.475	5.2	6.6	7.5	0.133
Other	3.8	5.9	8.7	0.001	0.8	2.7	3.7	<.001	1.2	1.6	2.7	0.042

Abbreviations: BMI, body mass index; NHANES, National Health and Nutrition Examination Surveys; ADL, activities of daily living; P1, Period 1 (1988-1994); P2, Period2 (1999-2004); P3, Period3 (2005-2012)

<sup>a</sup> Estimates reflect survey weighting and underweight is not shown.

<sup>b</sup> P-value for test of difference between periods 1 and 3.

<sup>c</sup> Values are expressed as mean.

**Table 2.** Relative Odds of Functional and ADL Impairment, Ages 60 Years or Older, NHANES, 1988-2012 (*N* = 16,770)<sup>a</sup>

Variable	Functional Impairment				ADL Impairment (severe)				ADL Impairment (moderate to severe)			
	Model 1		Model 2 <sup>b</sup>		Model 1		Model 2 <sup>b</sup>		Model 1		Model 2 <sup>b</sup>	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Underweight	1.57	1.15, 2.14	1.74	1.27, 2.38	1.53	0.90, 2.62	1.71	0.96, 3.06	1.56	1.16, 2.11	1.72	1.25, 2.38
Normal weight	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Overweight	1.22	1.10, 1.37	1.13	1.02, 1.26	0.92	0.70, 1.21	0.82	0.62, 1.09	1.01	0.88, 1.15	0.92	0.80, 1.05
Period 1 (1988-1994)	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Period 2 (1999-2004)	0.92	0.80, 1.05	0.86	0.74, 1.00	0.66	0.50, 0.88	0.63	0.47, 0.85	0.95	0.82, 1.11	0.90	0.76, 1.07
Period 3 (2005-2012)	0.91	0.79, 1.05	0.82	0.70, 0.95	0.72	0.56, 0.92	0.65	0.50, 0.86	0.95	0.81, 1.11	0.87	0.73, 1.03
Obese (in period 1)	1.96	1.62, 2.36	1.60	1.30, 1.96	1.31	0.93, 1.84	1.03	0.71, 1.49	1.51	1.23, 1.85	1.21	0.98, 1.50
Obese x period 2	1.58	1.27, 1.97	1.58	1.24, 2.03	1.55	1.03, 2.34	1.49	0.98, 2.24	1.61	1.22, 2.12	1.61	1.20, 2.15
Obese x period 3	1.46	1.18, 1.81	1.39	1.10, 1.76	1.55	1.02, 2.35	1.40	0.91, 2.16	1.09	0.84, 1.40	1.01	0.77, 1.32
Arthritis			2.77	2.50, 3.07			2.64	2.19, 3.19			2.85	2.57, 3.15
Asthma			1.58	1.32, 1.90			1.29	1.02, 1.65			1.32	1.12, 1.55
Cancer			1.14	1.00, 1.29			1.16	0.94, 1.42			1.13	0.99, 1.30
Congestive heart failure			2.27	1.86, 2.76			1.48	1.05, 2.10			1.71	1.41, 2.07
Diabetes			1.65	1.42, 1.93			1.79	1.48, 2.17			1.53	1.35, 1.74
Heart attack			1.29	1.09, 1.54			1.22	0.96, 1.55			1.17	0.98, 1.40
Stroke			2.49	2.03, 3.05			2.98	2.28, 3.89			2.28	1.88, 2.76
<i>Obese (in period 2)<sup>c</sup></i>	3.10	2.69, 3.57	2.53	2.15, 2.99	2.02	1.44, 2.83	1.52	1.08, 2.15	2.43	1.96, 3.01	1.95	1.56, 2.43
<i>Obese (in period 3)<sup>c</sup></i>	2.87	2.51, 3.27	2.22	1.91, 2.58	2.02	1.44, 2.83	1.44	1.00, 2.07	1.64	1.36, 1.97	1.22	1.00, 1.50

Abbreviations: NHANES, National Health and Nutrition Examination Surveys ; ADL, activities of daily living; OR, odds ratio; CI, confidence interval.

<sup>a</sup> All models adjust for age, sex, race/ethnicity, education, poverty income ratio, and smoking.

<sup>b</sup> Model 2 adjusts for conditions and otherwise has the same parameters as Model 1. Cells are empty when a variable is not in the model.

<sup>c</sup> Obese in periods 2 and 3 reflect the product of its main effect and the interaction term with period.

**Table 3.** Population Attributable Fraction for Obesity, Ages 60 Years or Older, NHANES, 1988-2012 (*N* = 16,770)<sup>a</sup>

Time	Functional Impairment		ADL Impairment (severe)		ADL Impairment (moderate to severe)	
	PAF (%)	95% CI	PAF (%)	95% CI	PAF (%)	95% CI
Period 1 (1988-1994)	9.8	7.0, 12.6	6.1	-2.1, 13.5	7.9	3.8, 11.7
Period 2 (1999-2004)	21.2	18.8, 23.6	21.5	10.5, 31.1	21.9	16.6, 26.9
Period 3 (2005-2012)	23.2	20.5, 25.7	24.6	12.3, 35.2	14.2	8.7, 19.3
	<b><i>P</i>-value<sup>b</sup></b>		<b><i>P</i>-value<sup>b</sup></b>		<b><i>P</i>-value<sup>b</sup></b>	
Period 1 vs 2	<.001		0.023		<.001	
Period 2 vs 3	0.293		0.692		0.041	
Period 1 vs 3	<.001		0.012		0.063	

Abbreviations: NHANES, National Health and Nutrition Examination Surveys ; ADL, activities of daily living; PAF, population attributable fraction; CI, confidence interval.

<sup>a</sup> All estimates adjust for age, sex, race/ethnicity, education, poverty income ratio, and smoking.

<sup>b</sup> *P*-values for test of difference in PAF between periods.



**Figure 1.** Predicted probability of (A) functional impairment, (B) severe activities of daily living (ADL) impairment, and (C) moderate to severe ADL impairment, by BMI group and period, ages 60 years or older, National Health and Nutrition Examination Surveys, 1988-2012. Values are adjusted for age, sex, race/ethnicity, education, poverty income ratio and smoking. Error bars represent 95% confidence intervals. Test for 1988-1994 vs. 2005-2012 in functional impairment: normal weight ( $P=0.195$ ), obese ( $P=0.004$ ); severe ADL impairment: normal weight ( $P=0.015$ ), obese ( $P=0.585$ ); and moderate-severe ADL impairment: normal weight ( $P=0.494$ ), obese ( $P=0.809$ ).

A)

B)

C)